Heavy Flavor Averaging Group (HFAG)

PDG Collaboration/Advisory Meeting
CERN
October 10-11, 2008

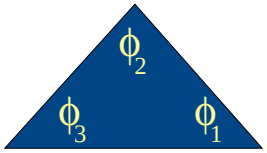
Co-leaders (from 2007): ***Alan Schwartz,*** *University of Cincinnati*
GianLuca Cavoto, *INFN, Roma*

2005-2007: *Soeren Prell, Simon Eidelman*
2002-2005: *David Kirkby, Yoshihide Sakai*

Goal: ***provide up-to-date world averages for measurements of B, D, and τ meson related quantities. Results can be freely quoted by conference speakers, theorists, etc.***

We use the latest conference results in averages; however, if a result is not submitted for publication within ~a year of presentation, we withdraw it from world averages.

For averages, we do not inf late errors.



Organization

7 Subgroups:

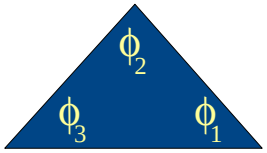
- *B Lifetimes and Mixing*
- *Semileptonic B Decays*
- *Unitarity Triangle*
- *Rare B Decays*
- *B to c Decays*
- *Charm Physics*
- *Tau Physics (new, just convened at TAU08)*

Subgroups update their websites typically 2-3 times/year, e.g., after Moriond, after ICHEP/LP, sometimes after FPCP/CKM, etc.
(http://www.slac.stanford.edu/xorg/hfag/)

These provide world averages for review speakers

Once a year (late spring), all results are collected together in one paper and posted to hep-ex:
(this year: E. Barberio et al., "Averages of b-hadron and c-hadron Properties at the End of 2007," arXiv:0808.1297)

Provide averages for the PDG (next slide)



HFAG and the PDG

HFAG now provides averages to the PDG (contact: Weiming Yao)

The averages provided include:

A. Lifetimes and Oscillations:

- *b lifetimes*
- *B mixing parameters*
- *b production fraction*

B. UT Triangle:

- *Sin2β (B^0 to ccbar K^0)*
- *$|\lambda|$ (B^0 to ccbar K^0)*

C. Charm:

- *mixing parameters x, y*
- *strong phases $\delta_{K\pi}$, $\delta_{K\pi\pi}$*
- *CPV parameters $|q/p|$, ϕ*

D. Semileptonic decays:

- *$|V_{cb}|$ x F(1) for B^0 to D*- l+ ν with ρ^2 and correlation*
- *$|V_{cb}|$ x F(1) for B^0 to D- l+ ν with ρ^2 and correlation*

- *Exlcusive B(B^0 to D- l+ ν)*
- *Exclusive B(B^0 to D*- l+ ν)*
- *Exclusive B(B^+ to D0 l ν)*
- *Exclusive B(B^+ to D*0 l ν)*

- *Exclusive B(B^+ to D- π+ l ν)*
- *Exclusive B(B^+ to D*- π+ l ν)*
- *Exclusive B(B^0 to D0 π+ l ν)*
- *Exclusive B(B^0 to D*0 π+ l ν)*

- *Inclusive B(B^0/B^+ to l+ ν X)*

-*V_{ub} for inclusive and exclusive b to u l ν decays*
- *Exclusive B(B^0 to π- l+ ν)*
- *Exclusive B(B^0 to ρ- l+ ν)*

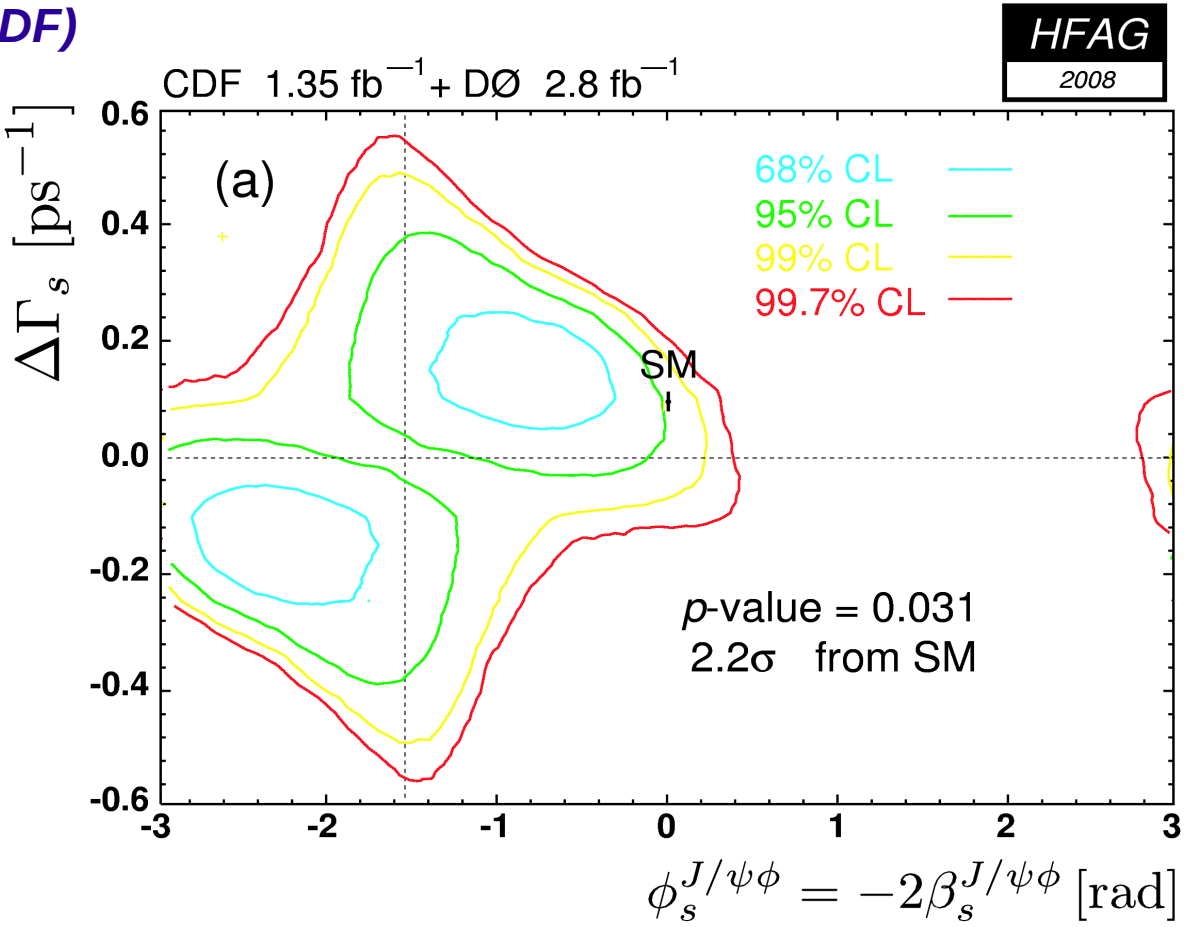
HFAG: Lifetimes and Mixing

Members:

- Olivier Schneider (convener, Belle)
- R. Godang (Babar)
- G. Gomez-Ceballos (CDF)
- R. van Kooten (D0)
- C. Weiser to R. Tesarek (CDF)

Tasks:

- b-hadron lifetimes
- b-hadron fractions
- B_d mixing, CPV
  - ($\Delta\Gamma$, Δm, $|q/p|$)
- B_s mixing, CPV
  - ($\Delta\Gamma_s$, Δm_s, $|q/p|$, β_s)



HFAG: UT Triangle

Members:

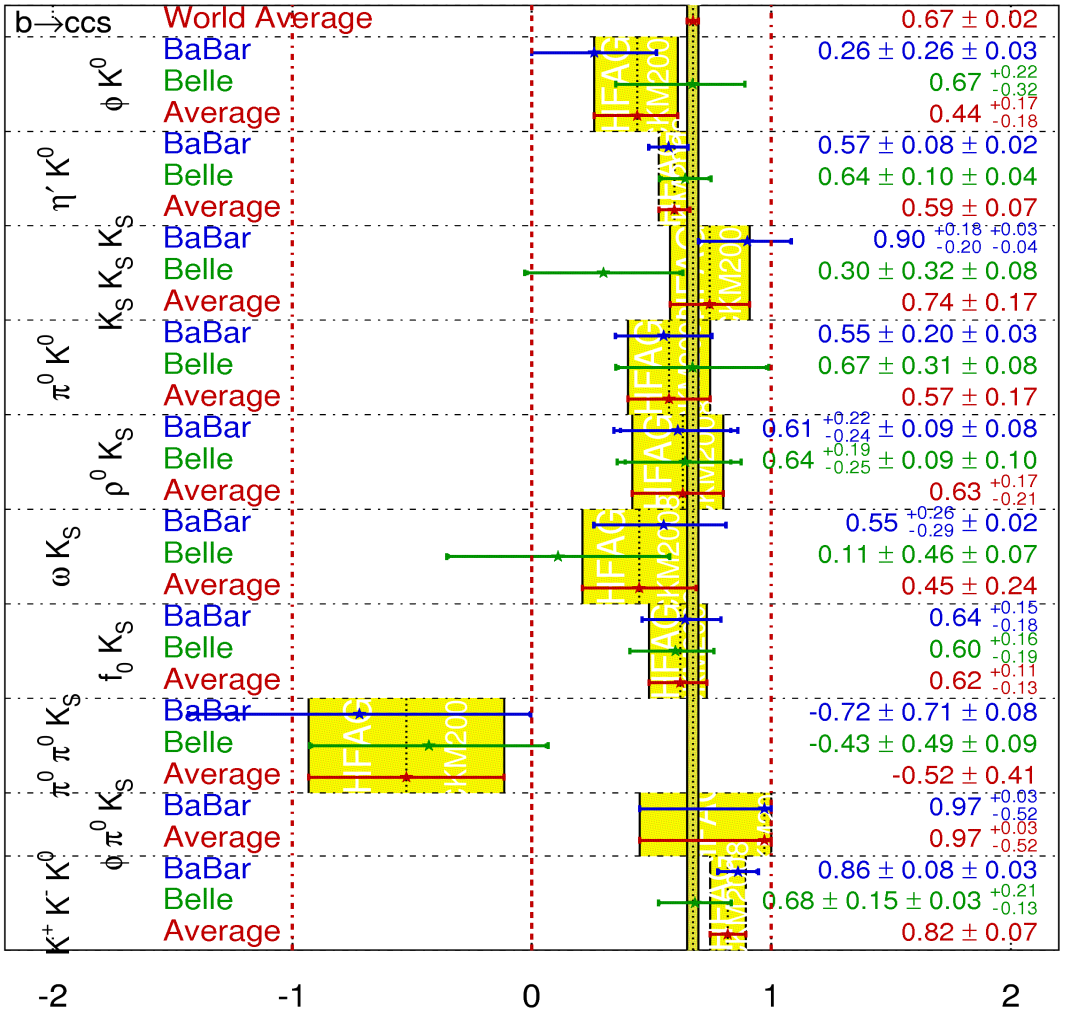
- Tim Gershon (convener, Babar)
- G. Cavoto (Babar)
- O. Long (Babar)
- D. Tonelli (CDF)
- K. Trabelsi (Belle)

Tasks:

- ϕ_1 (α)
- ϕ_2 (β)
- ϕ_3 (γ)

$$\sin(2\beta^{\text{eff}}) \equiv \sin(2\phi_1^{\text{eff}})$$

HFAG CKM2008 PRELIMINARY



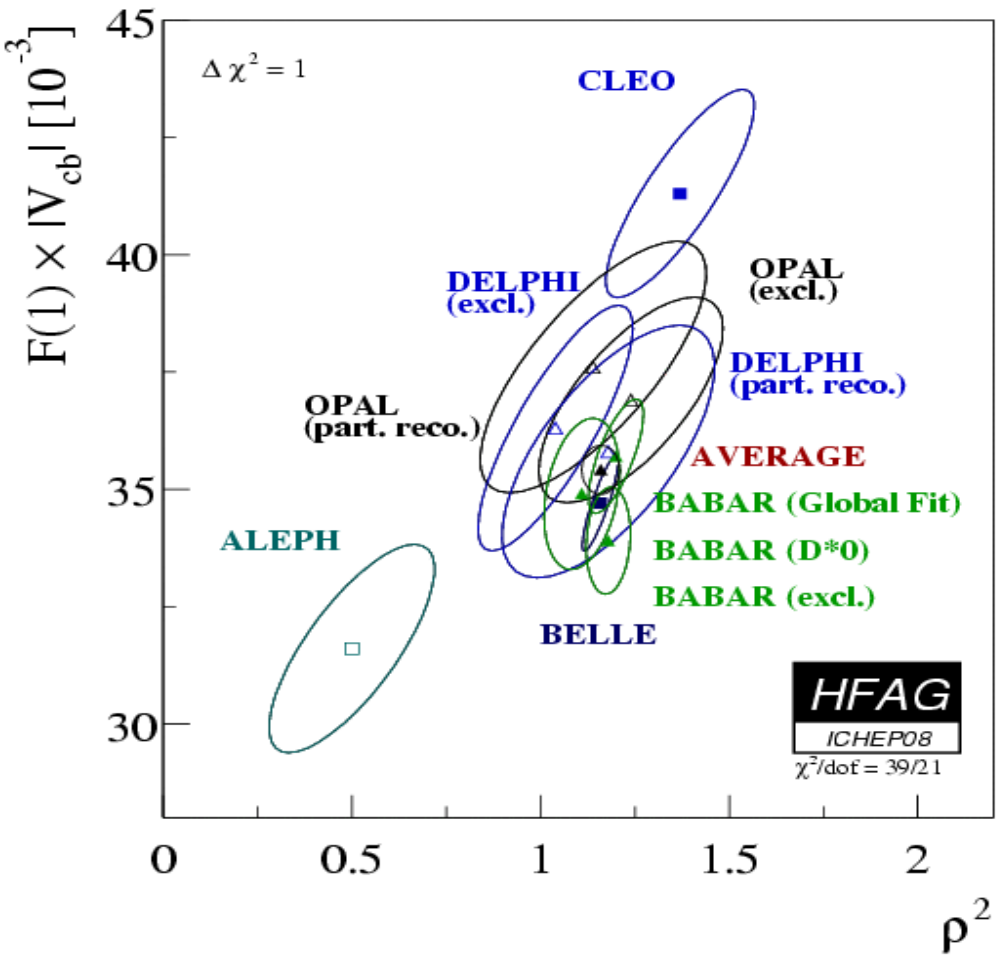
HFAG: Semileptonic

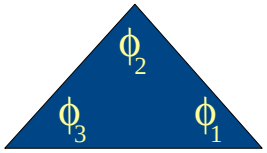
Members:

- Christoph Schwanda (co-convener, Belle)
- David Lopez-Pegna (co-convener, Babar)
- E. Barberio (Belle)
- O. Buchmueller (Babar)
- F. di Lodovico to C. Bozzi (Babar)
- H. Flaecher (Babar)
- R. Kowalewski (Babar)
- H. Lacker (Babar)
- V. Luth (Babar)
- A. Snyder (Babar)
- P. Urquijo (Belle)

Tasks:

- Branching fractions inclusive
- Branching fractions exclusive
- $|V_{cb}|$
- $|V_{ub}|$
- Moments





HFAG: b to c

Members:

Simon Blyth (convener, Belle)
C.-J. Lin (CDF)
S. Tosi (Babar)
C. Voena (Babar)

Tasks:

Branching fractions (w/averages), exclusive

Table 9: Branching fractions of charged B modes producing $J/\psi(1S)$ in units of 10^{-4}, upper limits are at 90% CL. The latest version is available at: http://hfag.phys.ntu.edu.tw/b2charm/00104.html

Mode	PDG 2006	Belle	*BABAR*	CDF	Average
$\pi^-\pi^0 J/\psi(1S)$			< 0.073		$\mathbf{< 0.073}$
$J/\psi(1S)D^0\pi^-$	< 0.25	< 0.25	< 0.52		< 0.25
$J/\psi(1S)\phi(1020)K^-$	0.52 ± 0.17		$0.44 \pm 0.14 \pm 0.05 \pm 0.01$		0.44 ± 0.15
$J/\psi(1S)\pi^-$	0.49 ± 0.06	$0.38 \pm 0.06 \pm 0.03$	$0.54 \pm 0.04 \pm 0.02$		0.48 ± 0.04
$\rho^-(770)J/\psi(1S)$			$0.50 \pm 0.07 \pm 0.03$		$\mathbf{0.50 \pm 0.08}$
$J/\psi(1S)\eta K^-$	1.08 ± 0.33		$1.08 \pm 0.23 \pm 0.24 \pm 0.03$		1.08 ± 0.33
$J/\psi(1S)D^-$	< 1.20		< 1.20		< 1.20
$J/\psi(1S)\omega(782)K^-$			$3.50 \pm 0.20 \pm 0.40$		$\mathbf{3.50 \pm 0.45}$
$J/\psi(1S)K^-$	10.08 ± 0.35				10.26 ± 0.37
		$10.10 \pm 0.20 \pm 0.70 \pm 0.20$	$10.61 \pm 0.15 \pm 0.44 \pm 0.18$ [1]		
			$10.10 \pm 0.90 \pm 0.60$ [2]		
			$8.10 \pm 1.30 \pm 0.70$ [3]		
$J/\psi(1S)K^-\pi^+\pi^-$	10.7 ± 1.9		$11.60 \pm 0.70 \pm 0.90$	$6.9 \pm 1.8 \pm 1.2$	10.6 ± 1.0
$J/\psi(1S)K^{*-}(892)$	14.10 ± 0.80	$12.80 \pm 0.70 \pm 1.40 \pm 0.20$	$14.54 \pm 0.47 \pm 0.94 \pm 0.25$	$15.8 \pm 4.7 \pm 2.7$	14.03 ± 0.88
$J/\psi(1S)K_1^-(1270)$	18.0 ± 5.2	$18.0 \pm 3.4 \pm 3.0 \pm 2.5$			18.0 ± 5.2

[1] MEASUREMENT OF BRANCHING FRACTIONS AND CHARGE ASYMMETRIES FOR EXCLUSIVE B DECAYS TO CHARMONIUM (124M $B\bar{B}$ pairs) ; $B^- \to J/\psi K^-$ with J/ψ to leptons
[2] MEASUREMENT OF THE $B^+ \to \gamma\bar{p}K^+$ BRANCHING FRACTION AND STUDY OF THE DECAY DYNAMICS (232M $B\bar{B}$ pairs) ; $B^- \to J/\psi K^-$ with $J/\psi \to \gamma\bar{p}$
[3] Measurements of the absolute branching fractions of $B^\pm \to K^\pm X_{c\bar{c}}$ (231.8M $B\bar{B}$ pairs) ; $B^- \to J/\psi K^-$ (inclusive)

Table 10: Product branching fractions of charged B modes producing $J/\psi(1S)$ in units of 10^{-4}, upper limits are at 90% CL. The latest version is available at: http://hfag.phys.ntu.edu.tw/b2charm/00104.html

Mode	PDG 2006	Belle	*BABAR*	CDF	Average
$K^-h_c(1P)[J/\psi(1S)\pi^+\pi^-]$	< 0.034		< 0.034		< 0.034

Result published during/after 2006 *Result released during/after 2007* *Result published during/after 2007*

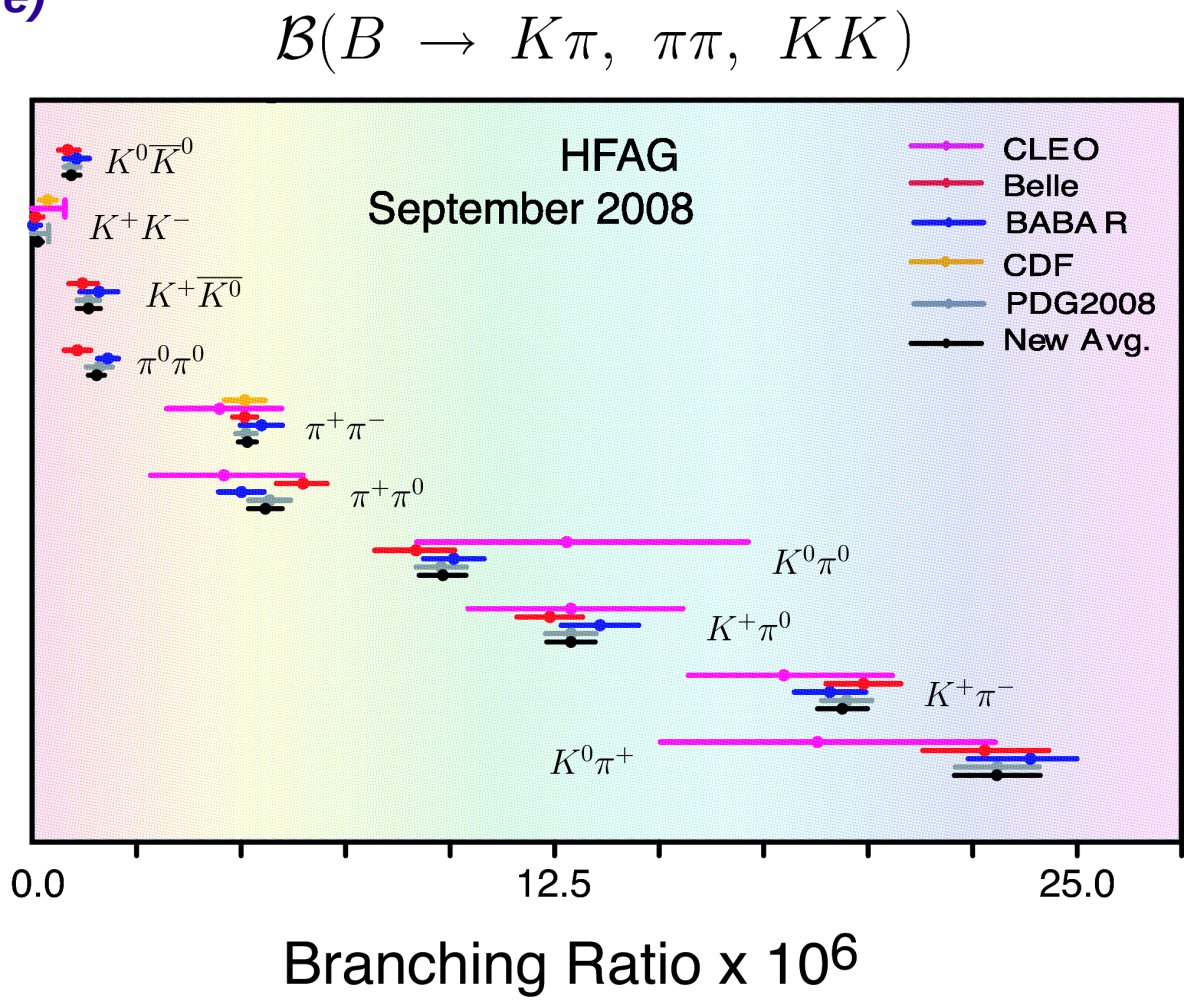
HFAG: Rare

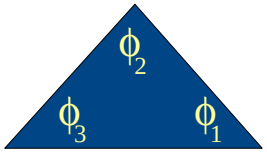
Members:

- Paoti Chang (convener, Belle)
- R. Bernhard (D0)
- R. Harr (CDF)
- J. Smith (Babar)

Tasks:

- Charmless mesonic decays
- Radiative decays
- Leptonic decays
- Baryonic decays
- A_{CP}
- Vector-vector polarization
- B_s decays





HFAG: Rare (cont'd)

Heavy Flavor Averaging Group

B^+ Branching Fractions (decays without kaons) ($\times 10^6$) - Sept. 2008. (UL 90% CL)

In PDG2008 New since PDG2008 (preliminary) New since PDG2008 (published)

RPP#	Mode	PDG2008 Avg.	BABAR	Belle	CLEO	CDF	New avg.
292	$\pi^+\pi^0$	5.7 ± 0.5	$5.02 \pm 0.46 \pm 0.29$	$6.5 \pm 0.4^{+0.4}_{-0.5}$	$4.6^{+1.8+0.6}_{-1.6-0.7}$		$5.59^{+0.41}_{-0.40}$
293	$\pi^+\pi^+\pi^-$	16.2 ± 1.5	$16.2 \pm 1.2 \pm 0.9$				16.2 ± 1.5
294	$\rho^0\pi^+$	8.7 ± 1.1	$8.8 \pm 1.0^{+0.6}_{-0.9}$	$8.0^{+2.3}_{-2.0} \pm 0.7$	$10.4^{+3.3}_{-3.4} \pm 2.1$		$8.7^{+1.0}_{-1.1}$
295	$\pi^+ f_0(980)$ †	< 3.0	< 3.0				< 3.0
296	$\pi^+ f_2(1270)$	8.2 ± 2.5	$8.2 \pm 2.1 \pm 1.4$				8.2 ± 2.5
297	$\rho(1450)^0\pi^+$	< 2.3	< 2.3				< 2.3
298	$f_0(1370)\pi^+$ †	< 3.0	< 3.0				< 3.0
299	$f_0(600)\pi^+$ †	< 4.1	< 4.1				< 4.1
300	$\pi^+\pi^-\pi^+(NR)$	< 4.6	< 4.6				< 4.6
302	$\rho^+\pi^0$	10.9 ± 1.4	$10.2 \pm 1.4 \pm 0.9$	$13.2 \pm 2.3^{+1.4}_{-1.9}$	< 43		$10.9^{+1.4}_{-1.5}$
304	$\rho^+\rho^0$	18 ± 4	$16.8 \pm 2.2 \pm 2.3$	$31.7 \pm 7.1^{+3.8}_{-6.7}$			18.2 ± 3.0
305	$\rho^+ f_0(980)$ †	< 1.9	< 1.9				< 1.9
306	$a_1(1260)^+\pi^0$	26 ± 7	$26.4 \pm 5.4 \pm 4.1$				26.4 ± 6.8
307	$a_1(1260)^0\pi^+$	20 ± 6	$20.4 \pm 4.7 \pm 3.4$				20.4 ± 5.8
308	$b_1^0\pi^+$ †	6.7 ± 2.0	$6.7 \pm 1.7 \pm 1.0$				6.7 ± 2.0
–	$b_1^+\pi^0$	New	< 3.3				< 3.3
309	$\omega\pi^+$	6.9 ± 0.5	$6.7 \pm 0.5 \pm 0.4$	$6.9 \pm 0.6 \pm 0.5$	$11.3^{+3.3}_{-2.9} \pm 1.4$		6.9 ± 0.5
310	$\omega\rho^+$	$10.6^{+2.6}_{-2.3}$	$10.6 \pm 2.1^{+1.6}_{-1.0}$		< 61		$10.6^{+2.6}_{-2.3}$
311	$\eta\pi^+$	4.4 ± 0.4	$5.0 \pm 0.5 \pm 0.3$	$4.2 \pm 0.4 \pm 0.2$	$1.2^{+2.8}_{-1.2}$		4.4 ± 0.4
312	$\eta'\pi^+$	2.7 ± 1.0	$3.9 \pm 0.7 \pm 0.3$	$1.8^{+0.7}_{-0.6} \pm 0.1$	$1.0^{+5.8}_{-1.0}$		$2.7^{+0.6}_{-0.5}$
313	$\eta'\rho^+$	$8.7^{+3.9}_{-3.1}$	$8.7^{+3.1+2.3}_{-2.8-1.3}$	< 5.8	$11.2^{+11.9}_{-7.0}$		$9.1^{+3.7}_{-2.8}$
314	$\eta\rho^+$	5.4 ± 1.9	$9.9 \pm 1.2 \pm 0.8$	$4.1^{+1.4}_{-1.3} \pm 0.4$	$4.8^{+5.2}_{-3.8}$		6.9 ± 1.0
315	$\phi\pi^+$	< 0.24	< 0.24		< 5		< 0.24
316	$\phi\rho^+$	< 16	< 3.0		< 16		< 3.0
317	$a_0(980)^0\pi^+$ †	< 5.8	< 5.8				< 5.8
318	$a_0(980)^+\pi^0$ †	< 1.4	< 1.4				< 1.4

†Product BF - daughter BF taken to be 100%;

HFAG: Charm

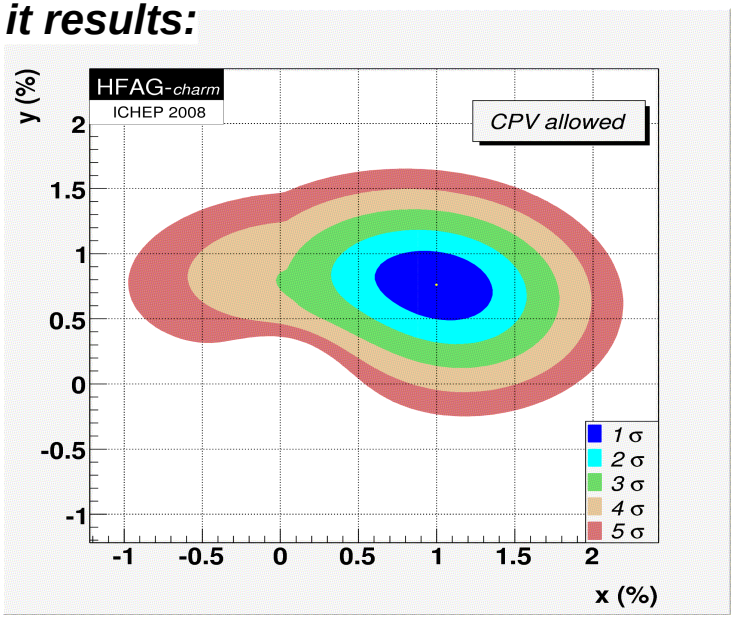
Members:

- Alan Schwartz (convener, Belle)
- D. Asner (CLEO)
- B. Casey (D0)
- D. Cassel (CLEO)
- J. Coleman (Babar)
- L. Gibbons (CLEO)
- B. Golob (Belle)
- D. Pedrini (FOCUS)
- M. Purohit (Babar)

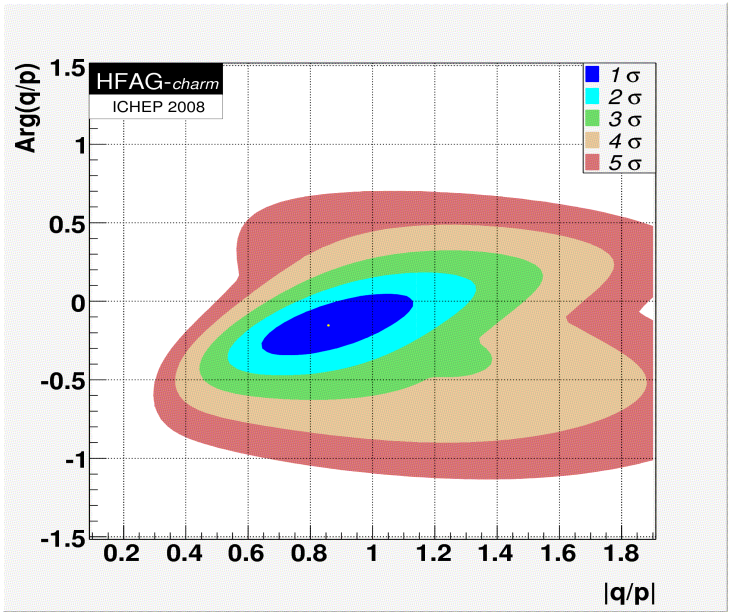
Tasks:

- Mixing
- CPV in mixing/interference
- Direct CPV
- Semileptonic (form factors)
- Decay constants
- Excited D's (D**, D_{sJ})
- Rare decays
- Charm baryons

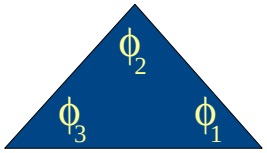
Global f it results:



no mixing excluded at 9.8σ



consistent with no CPV



HFAG: Future

- *Tau subgroup just convened (TAU08)*
- *New B_s results from full CDF/D0 data set*
- *New ϕ_3 (γ) results with input from CLEOc*
- *New charm mixing results from BESIII (input to global f it)*
- *New B, D, τ results from full Babar data set*
- *New B, D, τ results from full Belle data set (still going)*
- *Many new B_d, B^+, B_s measurements expected from LHCb*

HFAG should be busy for several years to come

- *Interaction with PDG seems very productive, but probably could be streamlined/optimized*